

WHAT IS CLAIMED IS:

1. A magnetization reversal method of applying an external magnetic field to a magnetoresistive film;

wherein said magnetoresistive film has a structure  
5 in which a nonmagnetic film is placed between magnetic  
films with an easy axis of magnetization along a  
perpendicular direction to a film plane and wherein  
said external magnetic field comprises magnetic fields  
10 from a plurality of directions including a direction of  
the easy axis of magnetization of said magnetic films.

2. The magnetization reversal method according to  
Claim 1, wherein said magnetic field applied in said  
direction of the easy axis of magnetization comprises  
15 magnetic fields applied by a plurality of magnetic  
field applying means.

3. The magnetization reversal method according to  
Claim 1, wherein said magnetoresistive film further  
20 comprises a magnetic layer with greater longitudinal  
magnetic anisotropy than that of said magnetic films,  
between said magnetic film and the nonmagnetic film.

4. The magnetization reversal method according to  
25 Claim 3, wherein said magnetic film and said magnetic  
layer with greater longitudinal magnetic anisotropy are  
exchange-coupled with each other.

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5. The magnetization reversal method according to Claim 1, wherein said nonmagnetic layer is an insulator.

5 6. The magnetization reversal method according to Claim 1, wherein said external magnetic field comprises magnetic fields generated by electric currents flowing in conductor lines.

10 7. A magnetization reversal method of applying a magnetic field from outside to a magnetic film to change a direction of magnetization, wherein magnetic fields are applied from a plurality of directions to said magnetic film and intensities of the respective  
15 magnetic fields are varied to effect reversal of magnetization in said magnetic film.

20 8. The magnetization reversal method according to Claim 7, wherein at least one magnetic field is a first magnetic field applied with variation in intensity during a period of complete reversal of magnetization in said magnetic film and another magnetic field is a second magnetic field applied in a fixed intensity and thereafter retained in the intensity of the magnetic  
25 field during the period of complete reversal of magnetization in said magnetic film.

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9. The magnetization reversal method according to Claim 7, wherein an easy axis of magnetization of said magnetic film is a perpendicular direction to a film plane.

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10. The magnetization reversal method according to Claim 7, wherein said magnetic film has a structure in which a nonmagnetic layer is placed between a plurality of magnetic layers.

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11. The magnetization reversal method according to Claim 10, wherein said magnetic film is a magnetoresistive film.

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12. The magnetization reversal method according to Claim 10, wherein said magnetic layer has an easy axis of magnetization along a perpendicular direction to a film plane.

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13. The magnetization reversal method according to Claim 12, wherein a magnetic layer with greater longitudinal magnetic anisotropy than that of said magnetic layers is further placed between said magnetic layer and said nonmagnetic layer.

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14. The magnetization reversal method according to Claim 8, wherein said second magnetic field is

applied in a direction of easy magnetization of said magnetic film.

15. The magnetization reversal method according  
5 to Claim 14, wherein said plurality of applying  
directions of the magnetic fields include a direction  
inclined from the direction of easy magnetization of  
said magnetic film, the magnetic fields are  
simultaneously applied in the direction of easy  
10 magnetization of said magnetic film and in the  
direction inclined from the easy axis of magnetization,  
the application of the magnetic field in the direction  
inclined from the easy axis of magnetization is first  
stopped, and thereafter the application of the magnetic  
15 field in the direction of easy magnetization is  
stopped.

16. The magnetization reversal method according  
to Claim 7, wherein said magnetic fields are magnetic  
20 fields generated by electric currents flowing in  
conductor lines.

17. A magnetization reversal method of applying a  
magnetic field from outside to a magnetic film with an  
25 easy axis of magnetization along a perpendicular  
direction to a film plane to change a direction of  
magnetization, wherein said magnetic field applied is a

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magnetic field from a direction inclined from the easy axis of magnetization of said magnetic film.

18. The magnetization reversal method according to Claim 17, wherein said magnetic film is a magnetoresistive film in which a nonmagnetic layer is placed between a plurality of magnetic layers.

19. The magnetization reversal method according to Claim 17, wherein said magnetic field is a magnetic field generated by an electric current flowing in a conductor line.

20. A magnetoresistive film comprising a first magnetic film and a second magnetic film with an easy axis of magnetization along a perpendicular direction to a film plane, and having a structure in which a nonmagnetic layer is placed between said first magnetic film and second magnetic film.

wherein a magnetization reversal magnetic field of said first magnetic film < a magnetization reversal magnetic field of said second magnetic film, and wherein said second magnetic film undergoes reversal of magnetization by simultaneously applying the magnetization reversal magnetic field of said first magnetic film and a magnetic field inclined from the easy axis of magnetization.

21. The magnetoresistive film according to Claim 20, wherein a direction of the magnetic field inclined from the easy axis of magnetization is a longitudinal direction in the film plane of said magnetic film.

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22. The magnetoresistive film according to Claim 20, further comprising a magnetic layer with greater longitudinal magnetic anisotropy than that of said second magnetic film, between said second magnetic film and said nonmagnetic layer.

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23. The magnetoresistive film according to Claim 22, wherein said magnetic layer and said magnetic layer with greater longitudinal magnetic anisotropy are exchange-coupled with each other.

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24. The magnetoresistive film according to Claim 20, wherein said first and/or second magnetic film is a ferrimagnetic material.

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25. A magnetoresistive film comprising a first magnetic film and a second magnetic film with an easy axis of magnetization along a perpendicular direction to a film plane, and having a structure in which a nonmagnetic film is placed between said first magnetic film and said second magnetic film.

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wherein said first magnetic film undergoes

reversal of magnetization by applying a magnetic field in a direction of the easy axis of magnetization and a magnetic field in a direction inclined from the easy axis of magnetization, and wherein said second magnetic  
5 film does not undergo reversal of magnetization by the magnetic fields applied to said first magnetic film.

26. The magnetoresistive film according to Claim  
25, wherein the magnetic field in the direction  
10 inclined from the easy axis of magnetization is applied in a longitudinal direction in the film plane of said magnetic film.

27. The magnetoresistive film according to Claim  
15 25, further comprising a magnetic layer with greater longitudinal magnetic anisotropy than that of said first magnetic film, between said first magnetic film and said nonmagnetic film.

20 28. The magnetoresistive film according to Claim 27, wherein said first magnetic film and said magnetic layer with greater longitudinal magnetic anisotropy are exchange-coupled with each other.

25 29. The magnetoresistive film according to Claim 25, wherein said first and/or second magnetic film is a ferrimagnetic material.

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30. A magnetic memory comprising:

a substrate;

a magnetoresistive film provided on the substrate,  
which has a structure in which a nonmagnetic layer is  
5 placed between a plurality of magnetic films with an  
easy axis of magnetization along a perpendicular  
direction to a film plane;

a write line for applying a magnetic field to said  
magnetoresistive film; and

10 a bit line provided on the opposite side to said  
substrate with respect to the magnetoresistive film,

wherein magnetization in at least one magnetic  
film of said magnetoresistive film is reversed by  
magnetic fields generated by electric currents flowing  
15 in said write line and in said bit line.

31. A magnetic memory comprising:

a substrate;

a magnetoresistive film provided on the substrate,  
20 which has a structure in which a nonmagnetic layer is  
placed between a plurality of magnetic films with an  
easy axis of magnetization along a perpendicular  
direction to a film plane;

a write line for applying a magnetic field to said  
25 magnetoresistive film; and

a bit line provided on the opposite side to said  
substrate with respect to the magnetoresistive film,

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wherein the magnetic field from said write line is applied in a direction of the easy axis of magnetization of said magnetic films of said magnetoresistive film and a magnetic field from said bit line is applied in a direction inclined from the easy axis of magnetization.

32. The magnetic memory according to Claim 30 or 31, wherein said nonmagnetic film is an insulator.

33. The magnetic memory according to Claim 30 or 31, wherein said write line is shared between adjacent magnetoresistive films.

34. The magnetic memory according to Claim 30 or 31, further comprising a magnetic layer with greater longitudinal magnetic anisotropy than that of said magnetic film, between said magnetic film and nonmagnetic layer.

35. The magnetic memory according to Claim 34, wherein said magnetic film and said magnetic layer with greater longitudinal magnetic anisotropy are exchange-coupled with each other.

36. The magnetic memory according to either one of Claims 30, 31, and 34, wherein said magnetoresistive

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film is a magnetoresistive film in which at least one magnetic film undergoes reversal of magnetization by a magnetic field in a direction of the easy axis of magnetization and in which another magnetic film  
5 undergoes reversal of magnetization by applying both the magnetic field in the direction of the easy axis of magnetization and the magnetic field inclined from the direction of the easy axis of magnetization,

wherein recording of information is implemented by  
10 applying the magnetic field in the direction of the easy axis of magnetization and the magnetic field in the direction inclined from the direction of the easy axis of magnetization, and reproduction of information is implemented by applying only the magnetic field in  
15 the direction of the easy axis of magnetization.

37. The magnetic memory according to either one of Claims 30, 31, and 34, wherein said magnetoresistive film is a magnetoresistive film in which at least one  
20 magnetic film undergoes reversal of magnetization by applying the magnetic fields in the direction of the easy axis of magnetization and in the direction inclined from the direction of the easy axis of magnetization and in which another magnetic film does  
25 not undergo reversal of magnetization even by applying the same magnetic fields,

wherein recording and/or reproduction of

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information is implemented by applying the magnetic fields in the direction of the easy axis of magnetization and in the direction inclined from the easy axis of magnetization.

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38. The magnetic memory according to Claim 30 or 31, wherein a plurality of magnetoresistive films are arrayed in a matrix pattern on said substrate.

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39. The magnetic memory according to Claim 38, wherein during recording of information, electric currents are made to flow in said bit line and in said write line to apply magnetic fields, thereby selecting a magnetoresistive film.

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40. The magnetic memory according to Claim 39, wherein the bit line for selection of the magnetoresistive film is a bit line connected to an adjacent magnetoresistive film.

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41. The magnetic memory according to Claim 39, wherein the bit line for selection of the magnetoresistive film is a bit line connected to the magnetoresistive film to be selected.

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42. The magnetic memory according to Claim 39, wherein the magnetic field from said bit line has a

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longitudinal component in the film plane of said  
magnetoresistive film.

43. The magnetic memory according to Claim 39,  
5 wherein the magnetic field from said bit line has a  
component along the direction of the easy axis of  
magnetization of said magnetoresistive film.

44. The magnetic memory according to Claim 39,  
10 further comprising a transistor connected to said  
magnetoresistive film.

45. The magnetic memory according to Claim 44,  
15 wherein said magnetoresistive film is formed  
immediately above a drain region of said transistor.

46. The magnetic memory according to Claim 45,  
20 wherein a source electrode line connected to a source  
region of said transistor also serves as said write  
line.

47. A magnetic memory comprising:  
a substrate;  
a magnetoresistive film formed on the substrate,  
25 which has a structure in which a nonmagnetic layer is  
placed between magnetic films with an easy axis of  
magnetization along a perpendicular direction to a film

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plane;

a write line for applying a magnetic field to said magnetoresistive film; and

a bit line provided on the opposite side to said  
5 substrate with respect to said magnetoresistive film,  
said magnetic memory comprising means for applying  
an external magnetic field to the magnetic films of  
said magnetoresistive film while varying an intensity  
or a direction of the external magnetic field.

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48. The magnetic memory according to Claim 47,  
wherein said nonmagnetic film is an insulator.

49. The magnetic memory according to Claim 47,  
15 wherein said write line is shared between adjacent  
magnetoresistive films.

50. The magnetic memory according to Claim 47,  
wherein said magnetoresistive film is placed so that  
20 magnetic fields from said write line and bit line are  
applied in the direction of the easy axis of  
magnetization and in a direction inclined from the  
direction of the easy axis of magnetization to said  
magnetoresistive film.

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51. The magnetic memory according to Claim 50,  
further comprising a magnetic layer with greater

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longitudinal magnetic anisotropy than that of said magnetic film, between said magnetic film and nonmagnetic layer.

5           52. The magnetic memory according to Claim 51,  
wherein the direction inclined from the easy axis of  
magnetization is a longitudinal direction in the film  
plane of said magnetic film and wherein during  
10       recording of information, application of the magnetic  
field in the longitudinal direction is first stopped  
and thereafter the application of the magnetic field in  
the direction of the easy axis of magnetization is  
stopped.

15           53. A magnetic memory comprising:  
a substrate;  
magnetoresistive films formed in a matrix pattern  
on the substrate;  
a write line for applying a magnetic field to said  
20       magnetoresistive films; and  
a bit line provided on the opposite side to said  
substrate with respect to said magnetoresistive films,  
wherein in said magnetoresistive films, a first  
magnetic film, a second magnetic film, a nonmagnetic  
25       film, a third magnetic film, and a fourth magnetic film  
are stacked in the order named, at least the first and  
fourth magnetic films have their easy axis of

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magnetization along a perpendicular direction to a film plane, and said second and third magnetic films have greater longitudinal magnetic anisotropy than that of said first and second magnetic films,

5            wherein at the same time as the magnetic field is applied in a direction of easy magnetization of said first and second magnetic films from said write line, a magnetic field is applied in a direction inclined from the easy axis of magnetization from said bit line, 10            thereby selecting a specific magnetoresistive film.

54. A magnetic memory comprising:

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15            a substrate, and a plurality of magnetoresistive films formed in a matrix pattern on the substrate, said magnetoresistive films each having a structure in which a nonmagnetic layer is placed between magnetic films with an easy axis of magnetization along a perpendicular direction to a film plane;

20            a write line for applying a magnetic field to said magnetoresistive films; and

            a bit line on the opposite side to said substrate with respect to said magnetoresistive films,

            wherein the magnetic field from said write line and a magnetic field from said bit line are 25            simultaneously applied, application of the magnetic field from the bit line is first stopped, and thereafter application of the magnetic field from the

write line is stopped after magnetization of said  
magnetoresistive films has been aligned in the  
direction of the magnetic field from said write line,  
thereby implementing recording or reproduction of  
information.

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